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EMPYEMA IN INFANTS AND YOUNG CHILDREN*

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In reviewing the literature on empyema in infants and young children, it was found that the number of extensive articles on this subject was surprisingly few. Since the majority of admissions to the Babies' Hospital are children under 3 years of age, an exceptional field is offered to observe this disease in the very young. For this reason it seemed worth while to make a study of the cases which have been treated during the last seven years. The cases treated prior to this time were analyzed in 1913 by Holt.[1]

From Jan. 1, 1913 to Jan. 1, 1920, 204 cases of clinical empyema were treated at the Babies' Hospital. Of this number 113 babies recovered and 91 died, a mortality of 44.6 per cent. Cases are classed as empyema in which pus or cloudy serum was obtained from the pleural cavity by exploratory punctures. From this pus or seropus bacteria were always grown. In six instances only a few cubic centimeters of cloudy serum were obtained, the infant recovering after puncture without the accumulation of more exudate in the pleural cavity. Cases of this type, from which bacteria were cultivated from the exudate, are included as examples of empyema.

INCIDENCE

The combined cases of pneumonia and empyema, which were admitted to the hospital during the period in which this series of cases was studied, numbered 1,869. Approximately, then, 11 per cent. of all the pneumonia patients either had an empyema at the time of admission or developed it in the hospital. This incidence of one empyema to nine pneumonias corresponds very closely to that of Dunlop,[2] who in a study of ninety-eight children with empyema found the frequency to be one empyema to every eight or nine pneumonias. Churchill,[3] on the contrary, states that this complication is relatively infrequent in children, empyema occurring once in every twenty cases of pneumonia.

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* From the records of the Babies' Hospital, New York.

1. Holt, L. E.: The Siphon Treatment of Empyema in Infants and Young Children Compared With Other Measures: A Study of 154 Cases, Am. Med. **8**:381 (June) 1913.

2. Dunlop, H. G. M.: Empyema in Children, Edinburgh M. J. **13**:1, 1914.

3. Churchill, F. S.: Empyema in Children with Special Reference to Diagnosis, Boston M. & S. J. **181**:87 (July 24) 1919.

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The mortality by ages is given in Table 1.

TABLE 1.—AGE AND MORTALITY

Months	Total Cases	Recovered	Died	Mortality, per Cent.
0- 3	3	1	2	66.7
3- 6	17	4	13	76.5
6-12	33	14	19	57.6
12-24	85	42	43	50.6
26-36	37	27	10	27.0
Over 3 years	29	25	4	13.8

This table shows that the age of the infant is perhaps the largest single factor concerned in determining the prognosis. Among the twenty patients under 6 months of age, the mortality was 75 per cent.; among the fifty-three infants under 1 year, the mortality was 64 per cent., while for the twenty-nine over 3 years of age, the mortality was only 13.8 per cent.

The youngest case in this series was an infant only 22 days old. He was a male child admitted when fourteen days old with diarrhea of two days duration. The admission weight was 7 pounds. The physical examination revealed a definite pulmonary consolidation at the right base. Eight days after admission the physical signs at the right base were suggestive of fluid. An exploratory aspiration was done and pus was obtained. Continuous drainage by the syphon method was instituted under local anesthesia. The tube remained in the chest for sixteen days. Three days after its removal the baby was discharged in good condition. The temperature ranged between 99 F. and 103 F. before operation. It became normal the day after operation and remained so until discharge. Two blood cultures gave negative results. The white blood count was 44,000; polymorphonuclears 84 per cent., lymphocytes 16 per cent., the day after admission. The organism found was *Staphylococcus aureus* in pure culture. The baby was breast fed while in the hospital, and weighed 6½ pounds on the day of discharge. An observation four months afterward showed that he was thriving satisfactorily.

There were four cases of recovery in infants between 3 and 6 months of age. Pneumococcus was the organism found in the pus from the pleural cavity in three cases, staphylococcus in one. Siphon drainage was the treatment employed in three of these, and the tube remained in the chest nine, fifteen and sixteen days respectively. In the fourth case, an infant 5 months old, two aspirations were done and a total of 9 c.c. of seropus containing many pneumococci was obtained. This patient recovered without the removal of any more fluid from the pleural cavity.

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SEX

There were 124 boys and 80 girls in this series. That the disease is so much more frequent in males than in females is rather surprising. The difference in this series is, however, not so marked as in the series of 154 cases reported by Holt,[1] in which 104 cases occurred in male infants and only 50 cases in females. The mortality for the males was 43.6 per cent., while that for the females was 46.3 per cent.

TABLE 2.—CONDITIONS ASSOCIATED WITH EMPYEMA

	Cases	Recovered	Died
Primary pneumonia	168	102	66
Pneumonia complicating measles	12	5	7
Pneumonia complicating whooping cough	4	2	2
Pneumonia complicating diphtheria	1	0	1
Pneumonia complicating varicella	1	0	1
Pneumonia complicating gastro-enteritis	9	3	6
Pneumonia complicating miliary tuberculosis	4	0	4
Pneumonia complicating retropharyngeal abscess	1	0	1
Pneumonia complicating tonsil and adenoid operation	2	1	1
Pneumonia complicating syphilis	2	0	2

Pneumonia was present in every case of this series. In 168 instances the pneumonia was primary and uncomplicated. Of these infants 102 recovered and 66 died, a mortality of 39 per cent. These cases are interesting when compared with those in which the pneumonia occurred as a complication of the common contagious diseases of childhood. In this group there were eighteen cases with eleven deaths, a mortality of 61 per cent. Contagious diseases are not admitted to the Babies' Hospital. This group is, therefore, very small. The high mortality is even more significant when the ages of these children are taken into consideration. The mortality for the twelve measles cases was 59 per cent. None of these children was under 1 year of age; eight of them were between 1 and 2 years old, and four were between 2 and 3 years old. The mortality for the children of this age in the entire series was 43 per cent.

DURATION OF SYMPTOMS BEFORE OPERATION

It is a general opinion that the duration of symptoms before operation is a matter of much importance in prognosis. The influence of the duration of the symptoms before the operation on the mortality of the 168 cases of empyema complicating primary pneumonia is shown in Table 3.

In three of these cases the duration of the respiratory symptoms was less than one week before operation. Such a rapid development of empyema to the point where operation is needed is not common. Details of these three cases are of considerable interest.

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TABLE 3.—EMPYEMA FOLLOWING PRIMARY PNEUMONIA, DURATION OF SYMPTOMS AND RESULTS

Duration of Symptoms	Cases	Recovered	Died	Mortality, per Cent.
0–1 week	3	1	2	67
1–2 weeks	36	17	19	53
2–4 years	80	51	29	36
4–6 weeks	30	23	7	23
6 weeks and over	19	10	9	47

REPORT OF CASES

CASE 1.—A male infant, aged 16 months, was admitted because of cough and fever for two days. The physical examination was suggestive of fluid in the right pleural cavity. An aspiration was done on the day of admission and 300 c.c. of pus was removed. Six days later 300 c.c. of pus was removed by a second aspiration. Eight days after admission siphon drainage was employed. The temperature became normal the second day after operation and the patient recovered. A culture of the pus from the chest showed a pure growth of pneumococci.

CASE 2.—A male infant, 3 months old, was admitted because of irritability and fever for one day. The physical signs of the left chest suggested fluid. Pus was obtained by an exploratory puncture the day after admission, and siphon drainage was employed. The infant died thirteen days after operation. The blood culture was sterile. The pus from the pleural cavity contained streptococci. The necropsy showed acute bronchopneumonia with fibrinopurulent pleurisy over both lobes of the left lung.

CASE 3.—A male infant, 4 months old, was admitted with a history of diarrhea for four days. Physical signs were typical of fluid in right chest posteriorly. Pus was obtained by an exploratory puncture two days after admission, and siphon drainage was employed. The infant died two days after operation. The pus from the chest contained streptococci. Necropsy showed fibrinopurulent peritonitis, fibrinopurulent pericarditis and extensive bronchopneumonia with fibrinopurulent pleurisy over the whole right lung. Streptococci were found in the culture of all these exudates.

In view of the fact that bronchopneumonia was present in the lung of the affected side in both cases which came to necropsy, the conclusion seems warranted that in none of these cases was the empyema primary. Every case of empyema in this hospital which has come to necropsy, showed the empyema to be secondary to pneumonia.

It is interesting to note in Table 3 that in those cases in which the symptoms had lasted less than six weeks before operation the mortality decreased with the duration of symptoms. In nineteen cases in which the symptoms had lasted six weeks or more before operation there was a mortality of 47 per cent. This is high when compared to a mortality of 23 per cent. in the thirty cases in which symptoms had lasted from four to six weeks before operation.

The high mortality of the cases in which symptoms were of short duration before the operation is undoubtedly due chiefly to the greater intensity of the infection. The high mortality in the cases in which operation was done late may be due to complications which interfere

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with expansion of the lung, chronic thickening of the pleura and pericardium, carnification of the lung, etc. The lowest mortality is seen in the middle group of cases. Early cases include those of greatest severity, and very late cases include the neglected ones.

LOCATION OF THE DISEASE

The left side of the chest was involved in 109 cases; the right in 91 cases; both sides were affected four times. These four cases of double empyema present some points of interest. Three of the cases were fatal. Two patients were treated by aspiration and one patient was treated by siphon drainage. In the patient who recovered the disease did not develop on the two sides simultaneously. Siphon drainage was the treatment employed, and the operations were twenty days apart.

PHYSICAL SIGNS

The most important physical signs of fluid in the pleural cavity of the young child are flatness on percussion, and displacement of the heart. It is a rule in the Babies' Hospital to do an exploratory puncture in every acute respiratory condition in which flatness to percussion is present. Of course, only by puncture can purulent and serous exudations be distinguished. Displacement of the heart is of great importance in diagnosis when present. But when the amount of pus present is small, and in a large number of the cases in young children the empyema is localized, the displacement is slight or absent altogether. This sign was absent in more than one third of the cases studied. Bronchial breathing is more often present than absent and while it is usually feeble and nasal in quality, it is very often indistinguishable from that which is heard over consolidation of the lung.

The type of infection has considerable influence on the mortality of this condition, as shown in Table 4.

TABLE 4.—BACTERIOLOGY AND MORTALITY

	Cases	Recovered	Died	Mortality, per Cent.
Pneumococcus alone	142	82	60	42
Staphylococcus alone	32	18	14	44
Streptococcus alone	20	9	11	55
Bacillus of Pfeiffer alone	2	1	1	50
Mixed Infections				
Streptococcus and pneumococcus	2	1	1	50
Pneumococcus and bacillus of Pfeiffer	5	1	4	80
Staphylococcus and bacillus of Pfeiffer	1	1	0	0

The pneumococcus was present in pure culture in 70 per cent. of the cases; and this group shows the lowest mortality in the series. The highest mortality, 62 per cent., was among the cases (eight)

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of mixed infection. The streptococcus cases showed the highest mortality of the single infections. There were twenty of these and their mortality was 55 per cent.

Holt [1] found that the staphylococcus infections were more frequent in the very young infants. The age and the type of infection in this series are given in Table 5.

TABLE 5.—AGE AND TYPE OF INFECTION

	First Year		Second Year		Third Year		Over Three Years	
	Cases	Died	Cases	Died	Cases	Died	Cases	Died
Pneumococcus.....	31	20	61	32	25	7	25	1
Staphylococcus.....	10	5	17	8	4	1	1	0
Streptococcus.....	9	7	3	1	6	1	2	2
Bacillus of Pfeiffer.	1	0	..	..	1	1		
Mixed infections....	2	2	4	2	1	0	1	1

This series of cases also shows a greater frequency of staphylococcus infections in the first and second years. Streptococcus infections are also more frequent during the first two years of life. Tubercle bacilli were not found in the pus in any instance, but general miliary tuberculosis was found at necropsy in four cases; the empyema, however, was non-tuberculous.

BLOOD EXAMINATION

A leukocyte count, together with the differential count, was made before operation in all but five cases.

The average count in cases ending in recovery was:

82 pneumococcus cases	31,900
18 staphylococcus cases	32,800
9 streptococcus cases	30,500
3 mixed infection cases	45,000

The average count in the fatal cases was:

58 pneumococcus cases	31,700
12 staphylococcus cases	37,500
10 streptococcus cases	44,000
5 mixed infection cases	23,000

Two cases with unusually low leukocyte counts are especially interesting. Both terminated fatally. One, a child of 3 years, had a leukocyte count of 7,200. The organisms present in the pus from the chest were pneumococcus and Bacillus of Pfeiffer. The case was complicated by a pneumococcus septicemia, pneumococcus pericarditis and miliary tuberculosis. In the other case, a child of 10 months, the leukocyte count was 9,800. A pure culture of pneumococci was grown from the pus obtained from the pleural cavity. Otitis media and ulcerative colitis were complications. The highest leukocyte count in the series was 83,000. This was seen in an infant 1 year old, who

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died the day after operation. Pneumococcus was present in the pus from the chest. This case was complicated by a pneumococcus septicemia with pneumococcus meningitis.

It is evident that no conclusion as to prognosis can be drawn from the leukocyte count. The leukocyte count is also of little value in making the diagnosis between empyema and pneumonia. In many instances the empyema developed in patients under observation without any noticeable increase in the leukocytosis.

Blood cultures were made in 115 of the cases studied, of which 43 were positive and 72 were negative. This type of infection, and the mortality are shown in Table 6.

TABLE 6.—Prognostic Value of Blood Cultures

	Negative Cases	Died	Positive Cases	Died
Pneumococcus alone	51	18	34	20
Streptococcus alone	9	6	2	2
Staphylococcus alone	10	4	4	3
Bacillus of Pfeiffer alone	1	0	1	1
Mixed infections	1	1	2	2

It is to be noted that fifteen of the infants with general blood infection recovered. The blood culture of fourteen of these showed pneumococci; of one, staphylococci. The majority of these blood infections were found in cases in which there was a rapid general infection, and in which the empyema developed as a complication in the earlier stages of the pneumonia.

TABLE 7.—Results With Different Methods of Treatment

Type of Treatment	Cases	Recovered	Died	Mortality, per Cent.
Siphon drainage	142	86	56	39.4
Simple incision and drainage	29	14	15	51.7
Rib resection	9	5	4	44.4
Aspiration	24	8	16	66.6

The majority of these cases, it will be seen, were treated by siphon drainage. This method of treatment has been described by Holt.[1] Simple incision between the ribs and the introduction of one or two short rubber tubes was the treatment employed in twenty-nine cases. Rib resection was the primary operation in only nine of these children. In twenty-four the only treatment was aspiration; the number of aspirations done on a single patient varied from one to six. Aspiration was the method of treatment used only in those infants who were so acutely ill that it seemed unwise to do a more serious operation. The mortality, 66.6 per cent., in this group is for

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this reason very high. In two of these cases (ages 7 and 13 months, respectively) 300 c.c. of pus were removed from the pleural cavity by three and four aspirations, respectively. Both these children recovered without other surgical interference. Pneumococcus was present in the pus from the chest of the younger, streptococcus in that from the chest of the older infant.

Dr. Homer F. Swift [4] in a study of pneumococcus empyema in adults, advises early operation as soon as the diagnosis has been made. In his experience all cases in which a pleural exudate containing bacteria was obtained, ultimately came to operation. This has not been the experience with infants and young children at the Babies' Hospital. In six cases a seropurulent exudate varying in amounts from a few drops to 15 c.c., and containing many pneumococci, was obtained by aspiration of the pleural cavity. These six patients recovered without any further removal of fluid.

TABLE 8.—AGE AND RESULTS BY DIFFERENT METHODS OF TREATMENT

Age	Siphon Drainage		Simple Incision with Drainage		Aspiration		Rib Resection	
	Cases	Died	Cases	Died	Cases	Died	Cases	Died
First year.....	36	20	8	7	9	7		
Second year.....	59	27	9	4	12	8	5	4
Third year.....	31	9	3	1	2	0	1	0
Over 3 years.....	16	0	9	3	1	1	3	0

It is to be noted in Table 8 that rib resection was not done on any infant under 1 year old. Yet the mortality for the nine children so treated is 44 per cent. Among those cases treated by siphon drainage and those by simple incision with drainage, the method chosen was not determined by the age; neither were certain types of cases, as mild or severe, chosen for the different methods of treatment.

The mortality of 39.4 per cent. in cases treated by syphon drainage is the lowest in the series. The best results with syphon drainage were obtained when this could be maintained without interruption as long as a week. The average number of days in which syphon drainage was maintained for the 86 cases who were treated by this method, and who recovered, was 6.4 days. In only fourteen of the fatal cases so treated was siphon drainage maintained six days or longer; and in all of these the fatal outcome was greatly influenced by complications. Siphon drainage has to be discontinued occasionally for one of two reasons: First, plugging of tube by masses of fibrin; second, air leakage around the tube due to faulty technic during operation or to ulceration around the tube.

4. Swift, H. F.: The Treatment of Empyema Caused by Pneumococci. Read before the New York Academy of Medicine, March 16, 1920.

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One of the greatest difficulties in the way of the recovery of young infants with empyema is imperfect pulmonary expansion due to the soft thoracic wall and to feeble respiratory muscles. Treatment by siphon drainage favors early and easy expansion. Cotton [5] believes that the proper utilization of the knowledge of pneumodynamics in the treatment of empyema in children will lower the mortality, decrease the number of chronic cases, and furnish adequate means of treating chronic cases without frequent resort to the radical and deforming operations of the past. The superiority of siphon drainage over any other method of treatment of empyema in early infancy used in this hospital has been clearly demonstrated, and the observations of Cotton seem justifiable. The observations of Kelly,[6] on the other hand, are hardly warranted when he says that "pumps, siphons, valves and suction apparatus are more bother than they are worth in children."

COMPLICATIONS

Table 9 shows how frequent complications are with empyema, and that death is often due to causes not connected with the pulmonary condition.

TABLE 9.—COMPLICATIONS

	Recovered	Died
Otitis media	33	24
Pneumonia in opposite lung	4	22
Gastro-enteritis	12	25
Diphtheria	1	6
Erysipelas	1	3
Acute nephritis	1	2
Bacillary dysentery	1	
Miliary tuberculosis	..	4
Ulcerative colitis	..	2
Congenital heart disease	..	1
Peritonitis	..	3
Retropharyngeal abscess	..	1
Congenital syphilis	..	2
Osteomyelitis of rib	..	1
Measles	..	1
Meningitis (pneumococcus)	..	2
Meningitis (streptococcus	..	1
Meningitis (tuberculosis)	..	1
Pyelitis	..	4
No complications	40	4

Of the infants who died, four had definite miliary tuberculosis, three had peritonitis (the organism in each case was the same as that present in the pus from the chest), two, age 3 months each, had congenital syphilis, and four had meningitis. The complications in thirteen of these infants, therefore, were of such severity that there

5. Cotton, F. J.: Pneumodynamics of Empyema, Boston M. & S. J. **173**:800, 1915.

6. Kelley, S. W.: Drainage of Acute Pleural Empyema in Children, Am. J. Surg. **26**:47, 1912.

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was little hope for their recovery whatever the treatment employed. The most interesting observation in Table 9 is the fact that among the fatal cases there were only four who did not present some serious lesion besides the pulmonary condition.

POSTMORTEM OBSERVATIONS

Necropsies were performed in sixty-four of the ninety-one fatal cases. These cases, grouped according to the anatomic diagnosis, are shown in Table 10. Lobar pneumonia was found in only three, while bronchopneumonia was present in fifty-five. This, of course, is due to the fact that bronchopneumonia is much more frequent during the first two years of life. It is interesting to note that Dunlop[2] states that empyema followed lobar pneumonia in 69 per cent of a series of ninety-eight cases studied by him. His series includes a much larger number of older children than does this series of cases.

TABLE 10.—NECROPSY FINDINGS IN SIXTY-FOUR FATAL CASES

	Cases
Bronchopneumonia	55
Lobar pneumonia	3
Carnification of the lung	10
Multiple pulmonary abscesses	8
Pseudomembranous pleurisy (Klebs-Loeffler origin)	1
Diphtheritic laryngitis	2
External pericarditis	20
Internal pericarditis	2
Miliary tuberculosis	4
Purulent peritonitis	8
Acute colitis	7
Purulent arthritis	1

Practically all cases coming to necropsy showed a fibrinopurulent pleurisy varying from a small amount of thin fibrin shreds to an extensive fibrinopurulent exudate, from 1 to 2 mm. in thickness; the lesion was double in nine cases. External pericarditis was found in twenty cases. This was more frequently found in those cases in which the left side was involved. Purulent peritonitis was present in eight cases; in five, this condition had not been recognized during life.

There was only one case of empyema necessitatis, or external opening through the thoracic wall in this series; and in no instance was there a rupture of the pus into a large bronchus or into the esophagus; nor did the pus burrow behind the diaphragm, causing a psoas or subdiaphragmatic abscess. Localized empyema was frequent. The pus cavity was localized in the majority of cases which came to necropsy; but in no instance was interlobar empyema seen either at necropsy or at operation.

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DURATION OF LIFE AFTER OPERATION IN FATAL CASES

Of the fatal cases treated by siphon drainage, twenty-three patients died within the first week, while twenty lived twelve days or longer after operation. All of the patients on whom rib resection was done lived longer than twelve days; and five of the cases treated by simple incision with drainage lived twelve days or longer. In nearly one third of these cases, then, the death was probably from exhaustion due to prolonged sepsis and to imperfect expansion of the affected lung. These patients died in spite of the fact that in every instance the drainage was perfect.

TIME OF OPERATION

It is the experience of the Babies' Hospital, unless the accumulation of fluid in the pleural cavity is very rapid, that the infant's chances of recovery are improved by delaying the operation until the acute inflammatory process in the lung itself has subsided. In some of these cases aspiration may be done for temporary relief, the opening of the chest being deferred.

CONCLUSIONS

1. The mortality of empyema in infants and very young children is high with all methods of treatment employed.

2. Approximately 11 per cent. of all the cases of pneumonia admitted to the Babies' Hospital during the last seven years either had empyema at the time of admission or developed it during the stay in the hospital.

3. The mortality in empyema decreases very rapidly as the age of the infant advances.

4. Empyema was the sequel of pneumonia in every case of this series. When pneumonia is a complication of the common infectious diseases of childhood the mortality is very high.

5. Pneumococcus in pure culture was present in the pus from the pleural cavity in 70 per cent. of these cases; the mortality for this type of infection is the lowest in the series.

6. The degree of leukocytosis is no guide to prognosis or to diagnosis.

7. In the experience of the Babies' Hospital siphon drainage has given better results in the treatment of empyema in infancy than any other method of treatment employed.

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